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REDUCING THE OIL CONTENT OF POTATO CHIPS BY CONTROLLING THEIR TEMPERATURE AFTER FRYING

by

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SUMMARY

Potato chips fried at a high temperature (350° F.) have a lower oil content than chips fried at (300° F.), according to tests confirmed by the Red River Valley Potato Processing Laboratory, East Grand Forks, Minnesota. The lower viscosity of the hotter oil favors more complete drainage of oil from the finished chip. By one or more of several treatments, chip temperature is increased after emerging from the frier resulting in a significant reduction in oil content. Flexibility of operation is improved, and economic savings may be realized in potato chip plants where oil costs per pound exceed potato solid costs per pound and in plants where reducing sugars cause use of lower frying temperatures. Less variability in oil content of product and greater plant throughput may also result.

INTRODUCTION

With an experimental multistage potato chip cooker, this laboratory confirmed that the oil content of finished chips resulting from high frying temperature (350° F.) was significantly lower than chips resulting from a lower frying temperature (300°). Though physical adsorption partly determines the oil content of finished potato chips, the oil content was also suspected as being a function of oil viscosity.

Smith (8, p. 294)[3] reviewed the literature on the effect of frying temperature on oil content of potato chips. Nearly all cases cited by Smith (8)--Williams (11), Rogers and coworkers (5), Sweetman (9), Lowe and coworkers (4), Whiteman and Wright (10), Johnson (2)--reported that higher oil temperature resulted in lower oil content of chips; one earlier report (12) found no relation.

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[2]A laboratory cooperatively operated by the Eastern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture; the Minnesota Agricultural Experiment Station; the North Dakota Agricultural Experiment Station; and the Red River Valley Potato Growers' Association, East Grand Forks, Minnesota.

[3]Underscored numbers in parentheses refer to Literature Cited at end of publication.

Smith (8, pp. 293-294) also reviewed the literature on effect of oil type on oil content of chips. As cited by Smith (8, p. 339), Whiteman and Wright (10) reported the oil content of six potato varieties from the 1947 crop that were fried in various oils. Average percentage values were cottonseed oil, 35.8; peanut oil, 36.8; shortening, 37.2; and corn oil, 38.5. Average percentage values from the 1948 crop were different with cottonseed oil, 38.2; shortening, 36; peanut oil, 36.7; and corn oil, 38.3 percent. Johnson (2) reported that cottonseed oil produced higher oil content in chips than hydrogenated lard. King (3) reported no difference for various oils.

No mention was made of the effect of oil viscosity per se on oil content of potato chips. This publication reports further experiments conducted at this laboratory on the effect of oil viscosity on oil content of potato chips. Methods used to minimize the oil retained on the product will also be described.

MATERIALS AND METHODS

The equipment consisted of a pilot plant chip cooker (fig. 1A, 1B, and 1C) comprised of a slicer (set for 0.035 in.), washer, dewatering shaker, cooker (with controlled chip-retention time), and a draining belt.

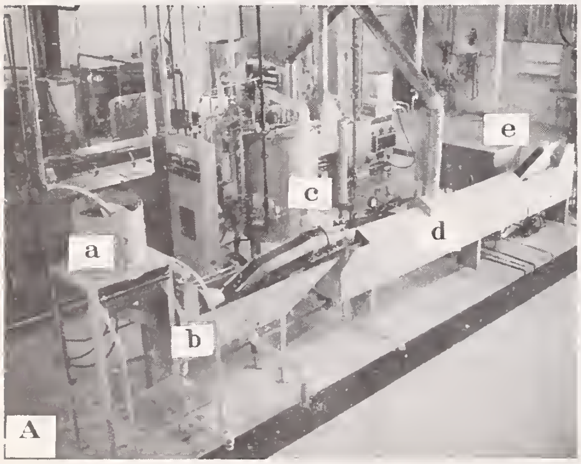
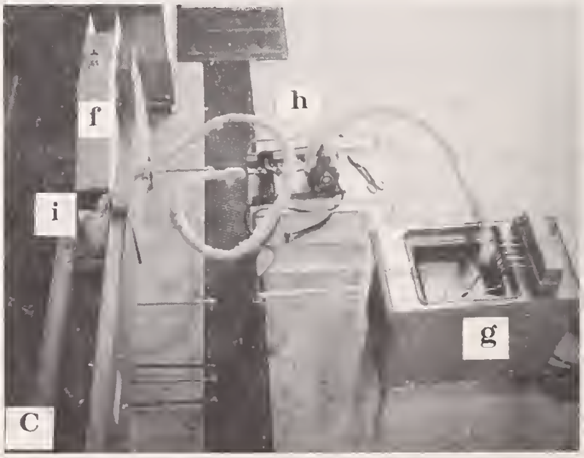


Figure 1. Pilot plant chip cooker:

A. a-slicer; b-washer; c-dewatering shaker; d-cooker; e-draining belt. (The oil douse and air oven were located over the draining belt).

B. f-hot air oven enclosing draining belt.

C. Hot oil douse showing g-heating kettle; h-pump; and i-weir. (The hot air oven (f) is also in place).



Supplemental oil (for dousing) was heated to the desired temperature (375° or 400°) in a separate thermostated electric kettle and pumped through insulated copper tubing to a trough with weir that evenly spread hot oil over the chips leaving the cooker.

The hot-air assembly consisted of a plywood frame lined with asbestos board, a 3200-watt electrical heating element, and a 15 SCFM squirrel cage fan for circulation (see fig. 2).

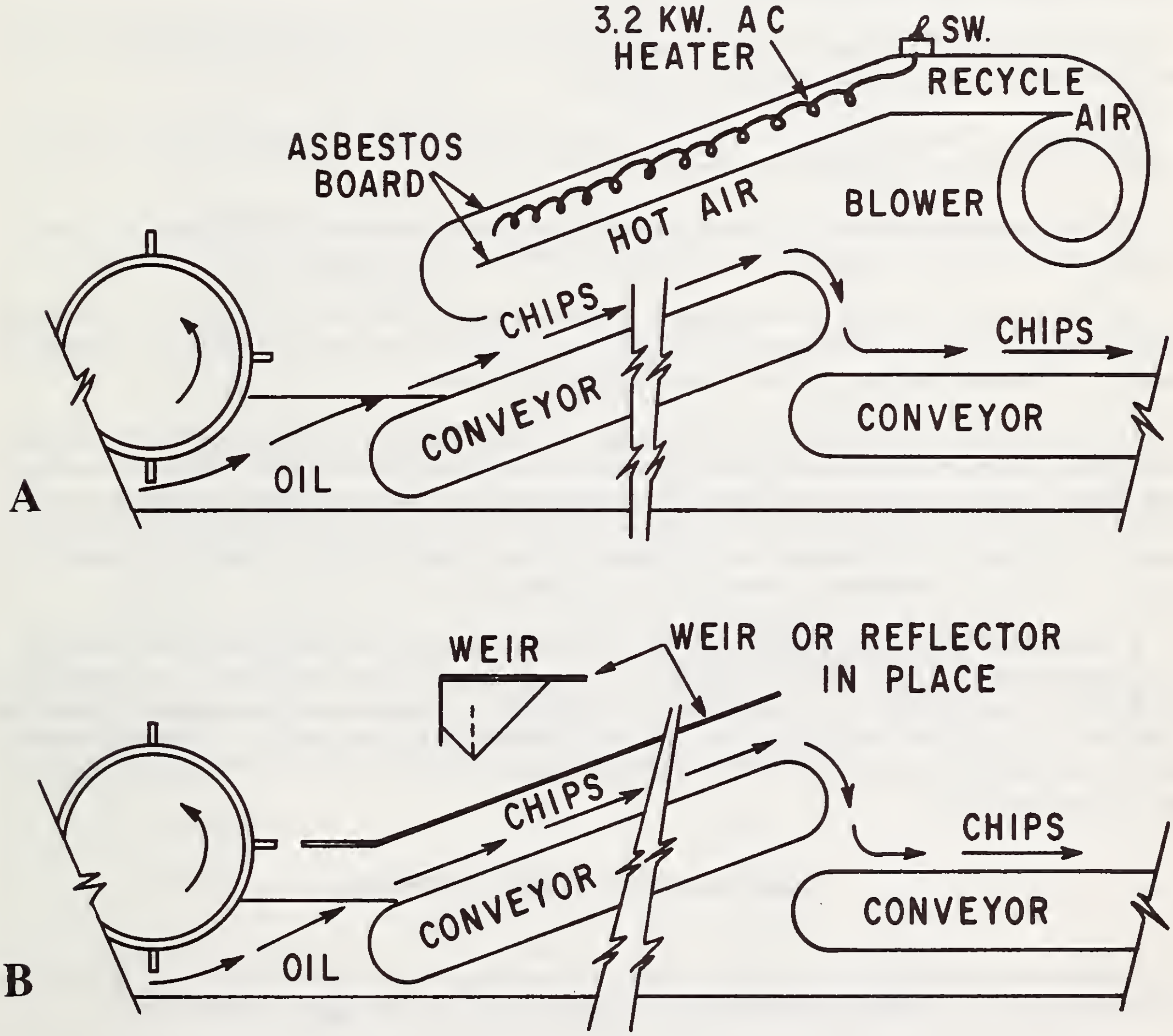


Figure 2. Diagram of chip heating system for pilot plant fryer:

A. Air heater unit and location on fryer.

B. Position of either weir or heat reflector on fryer.

For the "300" series of experiments, the pilot plant chip cooker was adjusted so that the oil temperature at the exit point was 300° F. This is close to exit temperature of chips fried under commercial conditions.

In the "300-375" series, the chip cooker was adjusted as above, but the oil douse at 375° F. was added as chips left the cooking oil.

The "300-375-A" series was run as the "300-375" series, except that the exiting chips passed through a 400° F. air oven.

During the "350" series, the pilot plant chip cooker was adjusted so that the oil temperature at the exit point of the chips was 350° F.

As with the "350" series, the "350-A" series chips left the cooker at 350° F.; but, in addition, the exiting chips passed through a 400° air oven.

All series samples were obtained under steady state conditions and enough samples taken to determine oil content at the 95 percent statistical confidence level.

Oil for the main series of tests was a blend of liquid cottonseed and corn oils obtained from a local chip plant. Other oils tested were acquired from various sources. Potatoes used were Kennebecs also obtained from a local chip plant.

The oil content of the finished potato chips was determined by the method of Ross and Treadway (7) which is a test for determining oil content of french fries. After consulting with Ross, this procedure was applied to measuring oil content of chips rather than the Ross and Treadway (6) method for oil determination in potato chips because it is somewhat easier. Further, since hexane was available, it was used in place of petroleum ether as a solvent, although hexane is somewhat more expensive.

A Brookfield viscometer was used to obtain preliminary data regarding the effect of temperature on viscosity of the cooking oil. Filter paper strips simulating chip texture were then dipped in the oil at various temperatures for 1 minute and permitted to drain for 1 minute. Subsequent weighings were made to determine oil retention. Viscosity (other than the preliminary test mentioned above) was determined with an ASTM Saybolt Universal viscometer (1).

RESULTS AND DISCUSSION

Results of preliminary tests using filter paper strips are shown in table 1. It is clear that oil retention is considerably lower for those dipped at the higher temperature.

Of the oils tested, the cottonseed oil (sample A) had the best drainage at 375° F. Safflower oil (sample D) was worst while the other oils were intermediate. Why one sample of cottonseed oil (sample A) had far better drainage than the other (sample C) is not known nor is it known if oil chemists can further lower oil viscosity in the temperature range of 250° to 400°.

Saybolt Universal viscosities of several vegetable oils (including the two partly hydrogenated samples B and E) as functions of temperatures are shown in table 2.

Table 1. Effect of Type of Oil and Its Temperature on Oil Retention in Filter Paper Strips Dipped 1 Minute and Drained 1 Minute.

Sample	Oil	Oil Content at 300° F.	Oil Content at 375° F.	Ratio 375°:300° F.
		Percent	Percent	
A	Cottonseed	53.0	49.2	0.928
B	Partly hydrogenated	52.1	50.4	0.967
C	Cottonseed	52.5	50.2	0.956
D	Safflower	52.9	51.1	0.966
E	Partly hydrogenated	52.8	50.7	0.960
F	Peanut	52.7	50.8	0.964
G	Soybean	51.9	50.3	0.969
H	Sunflower	52.5	50.4	0.960

Table 2. Viscosity-Temperature Relation for Several Vegetable Oils.

Sample	Oil	Saybolt Universal Viscosity 250° F.	300° F.	350° F.	400° F.
		Seconds	Seconds	Seconds	Seconds
A	Cottonseed	45.7	40.1	38.1	35.4
B	Partly hydrogenated	49.3	42.4	38.3	26.2
C	Cottonseed	47.4	42.2	38.2	36.3
D	Safflower	50.4	41.2	37.8	36.0
E	Partly hydrogenated	----	42.5	----	36.6
F	Peanut	47.2	41.4	38.2	35.8
G	Soybean	47.6	41.4	38.2	36.1

The effect of temperature on Saybolt Universal viscosity may not appear to be great in temperature range of 300° to 400° F., but close inspection of table 2 shows viscosity at 400° to be about 87 percent of that at 300° and at 350° to be about 91 percent of the 300° value. These differences may well result in significantly lower oil content of chips because of more rapid draining at the higher temperature. Accordingly, chips were fried under various processing conditions.

Table 3 shows the oil content of chips made under various processing conditions and indicates the oil content at the 95 percent confidence level.

Table 3. Oil Content of Potato Chips Under Various Processing Conditions

Series Identification	Trial Runs	Average Oil In Chips	Estimated Standard Deviation: s(x)	A	B[1]
	Number	Percent	Percent	Percent	Percent
Commercial[2]	40	36.7	2.7	35.3	38.1
"300"[3]	87	41.7	2.5	40.8	42.6
"300-375"[4]	51	34.1	5.2	31.7	36.5
"300-375-A"[5]	20	30.7	2.5	28.7	32.4
"350"[6]	84	40.2	2.4	39.4	41.1
"350-A"[7]	52	37.3	1.8	36.5	38.2

[1]Statistical results of an unsymmetrical "t-test" conducted such that the chance of the percent oil content of chips being less than "A" percent (or more than "B" percent) on the average is 0.05.

[2]Unsalted potato chips taken from the production line of a local commercial plant line on August 9, 1967, during steady state operation; inlet oil temperature 350° F., discharge oil temperature 300°.

[3]Pilot Plant Cooker Production: fryer exit temperature was 300° F.; holdup time in fat was 2 minutes; feed rate into cooker was 57.2 lb./hr.; production rate was 16.1 lb./hr.

[4]Same as "300" series except the product was doused in 375° F. oil upon emerging from the cooker. Contact time with hot oil was approximately 5 seconds.

[5]Same as "300-375" series, but retention time was ca. 1.2 minutes and the chips were passed through an oven of 400° F. air for 0.8 minutes.

[6]Pilot plant cooker production: Fryer exit temperature was 350° F.; holdup time in oil was 1.5 minutes; feed and production rate same as "300" series.

[7]Conditions of the "350" series were maintained, except the product was passed through an oven of 400° F. air after leaving the oil of the main fryer. Hot air exposure time was ca. 0.8 min.

The magnitude of the effect of viscosity on oil content of potato chips was considerable. Preliminary tests showed a significant 1 to 2 percent reduction of oil content, but after the equipment was operated at a steady state and a large number of samples were analyzed, it was realized that a chip plant could perhaps save 5 to 10 percent of its oil usage by one of several simple equipment modifications. Possibly, the same saving would hold in french-fry processing.

As the potato chip emerges from the fryer oil, the chip is still giving up moisture and hence tends to cool quite rapidly. This rapid cooling, by increasing oil viscosity and inhibiting oil drainage, creates the need for a device or method of keeping the chips hot. All that seems necessary is to keep the chips hot after they leave the cooking oil so that adequate drainage can occur. The data presented herein indicate the chances of successfully reducing oil content of the product are high and the savings significant, and the penalty for being wrong, minor.

Hot oil dousing is a very simple approach for any commercial chip cooker that uses an external oil heater. Part of the heated oil is simply piped to an overflowing trough with weir at the point where chips emerge from the cooking oil. This diverted oil of 360° to 375° F. is used to douse the chips emerging from 300° oil, the oil content of the chips being reduced by about 7 percent (table 4) as a result.

Table 4. Oil Reduction Using Same Statistical Assurance as in Table 2.

Sample	Treatment	Oil Content	Effect of treatment on average fat content, as percent of whole chip
		(percent)	
1	Fried at 300° F.	41.7 ± 2.5	-----------
2	1 + douse at 375°	34.1 ± 5.2	7.6 percent reduction
3	1 + 2, + air at 400°	30.7 ± 2.4	11.0 percent reduction

A refinement of hot oil dousing would be to put a booster heater in the oil line and douse with oil of 400° F.

Calculations reveal that about 0.4 gallons of 375° F. oil per pound of chips would be necessary to raise the chip temperature from 250° to 350°. To achieve the same temperature rise in the product with a 400° oil douse, only about 0.2 gallons per pound of chips would be needed. The calculations were based on the assumption that the chip composition is 35 percent oil, 65 percent potato solids, and 1 percent water. Further, it was taken that 10 percent of the heat contained in the hot oil would be non-effective because of losses, such as conduction through pipes and ineffective contacting with the chips.

The hot-oil douse functions only as a way to bring the chips more rapidly to desired temperature than by hot air. Oil used in the douse must also drain away and will do so more slowly as the chips cool after the douse. Additional oil drainage might be promoted by holding the chip temperature at the desired level for a sufficient time to allow further drainage. This might be done by hot air or infrared heating.

A hot-air heater as diagrammed in figure 2 was also found to be an effective approach to oil reduction in potato chips. (See table 2, 300°-375° vs. 300°-375°-A; 350° vs. 350°-A). The required parameters of heat and airflow were not established in this case. The unit used had much more wattage and air than necessary.

The effectiveness of a heat reflector was not tried, but can be deduced from the above and the following observations.

The temperature profile through a bed of chips emerging from a commercial fryer was monitored. At the upper surface of an 8-inch layer, the temperature was found to be ca 210° F.; near the conveying belt, the temperature was about 300°. It was also observed that the chips leaving the fryer in the above-mentioned plant were rather glossy and oily looking near the surface of the layer, and dull and "dry" looking near the conveyor (where the temperature was higher).

A reflector as diagrammed in figure 2 would increase temperature, thereby allowing better drainage. A refinement would be to put thermostated infrared elements on the reflector surface to get temperatures of about 400° F. A further refinement would be to install a small fan to dispel water vapor and to prevent condensation and drip-back. Essentially, this is the hot-air heater technique described above, but with a very minimum in heaters and fan capacity.

A slight darkening of product resulted from the heat treatments used in the pilot plant experiments. In large-scale production, a heat treating method may necessitate some modification of frying technique, to retain proper product color.

There does not appear to be any question that drainage of oil from potato chips is improved at higher finished potato chip temperatures that result in chips of significantly lower oil content.

The economics of the suggested heat treatments become even more attractive when it is realized that very little capital investment is required to put a method into operation. The finished chips would still be salable even if the method did not produce the desired improvement.

There are several advantages of such a heat process. For example, there is a realistic reduction in ingredient costs in plants where the oil cost per pound exceeds the potato solids cost per pound. At this writing, oil is $0.14 per pound. If potato solids are less than $0.14 per pound, then the oil can be reduced profitably; within the limits of product quality.

In plants where potatoes have a higher reducing sugar content than is desirable, the frying temperature has to be lowered to reduce browning. Such lower frying temperature results in increased oil content. This can be compensated for by one of the methods herein described, but one must guard against additional browning.

Because of retaining the heat and prolonging the heating time in these procedures, a commercial plant will find it necessary and desirable to shorten time in the fryer. The bed of chip exiting from a commercial fryer will also be maintained at a more uniform oil content.

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